Effect of problem and scripting-based learning combining wearable technology on orthopedic operating room nurses' learning outcomes

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ABSTRACT

Background: Orthopedic operating room (OR) nurses entail specialized skills and training, which are not part of the regular curricula at most nursing college. Instead, many nursing students' exposure to orthopedic care in the orthopedic range is limited to occasional observational assignments. Additionally, teamwork is an important factor affecting the performance of the orthopedic OR nurses. This results in a knowledge gap in clinical nursing education. Problem and scripting based learning (PSBL) method is a crucial tool of pre-operative prepared improvement. It is easy for surgeon to record surgical video from his own field of vision by wearable technology (WT). Nevertheless, few studies related to combine WT and PSBL been done to investigate features underlying efficiency in training of novice orthopedic OR nurses.
Objective: This study aimed to evaluate the feasibility of combining WT with PSBL in training of novice orthopedic OR nurses.
Methods: 20 operating room post-graduate-year-1 nurses from the First Hospital of China Medical University were randomly divided into two groups ("conventional training (CT)" group and "WT combining with PSBL" group). Initially the superior orthopedic operating room nurses who immediately followed each procedure filled out a feedback questionnaire of the novice nurses. After finished procedure, novice nurses had a basic understanding of each training method benefits and then filled out the questionnaires. Statistical analysis of the results was performed.
Results: Novice nurses of WT&PSBL Group got the better score in most of the preparedness and performance feedback statement. Mean scores of overall total preparedness and performance feedback statement of WT&PSBL Group was higher than CT Group ($P \leq 0.05$). Based on summarizing the questionnaires, the novice nurse in WT-PSBL Group also made significantly better total score than "Conventional training" Group ($P \leq 0.05$).
Conclusions: WT&PSBL method, as a crucial tool for improving pre-operative preparedness and intra-operative performance, can cultivate novice orthopedic operating room nurses' ability to use prior knowledge and cognitive frameworks flexibly to deal with problems during performance. It plays a crucial role in training confident and safe orthopedic operating room nurses.
Design: Randomized controlled trial (RCT).

1. Introduction

There was a serious shortage of orthopedic operating room nurses, and the demand for orthopedic operating room (OR) nurses in China are steadily growing per year.

Orthopedic OR nurses entail specialized skills and training, which are not part of the regular curricula at most college of nursing (Akhtar et al., 2015). Instead, many nursing students' exposure to orthopedic

care in the orthopedic range is limited to occasional observational assignments, which prevents them from understanding the role of OR nurses during orthopedic surgical procedures. This results in a knowledge gap in clinical nursing education. The limited orthopedic perioperative experience of nursing school teachers has also led to a lack of orthopedic perioperative nursing education in the academia community. In addition, because of the limited exposure to orthopedic perioperative practices, even nurses who have been performing general

surgical procedures for several years often do not know what is needed for orthopedic perioperative nursing practice (Ball et al., 2015).

A special function of the OR is to ensure that the orthopedic surgery nursing staffs have sufficient experience and training to optimally assist the orthopedic surgeon and provide optimal care to the surgery patient (Flurry et al., 2012). Additionally, teamwork is an important factor affecting the performance of the OR. Therefore, the ability of orthopedic surgery nurses to assist surgeons in the successful completion of operation is very important(Chang et al., 2017). College of Nursing face the challenge of teaching orthopedic OR nurses how to support orthopedic surgeons. Because learning usually happens by chance on-the-job encounters, there was no standard to train orthopedic OR nurses. As a result, outcomes of operation may be affected by inexperienced surgery nurse(Flurry et al., 2012)(Chang et al., 2017). As orthopedic OR nursing education faces such challenges, we need to develop new training methods to overcome these limitations.

The student-centered teaching method of problem-based learning (PBL) is becoming more and more popular in various medical courses (Kong et al., 2009). In order to generate cognitive stimuli of surgical residents, scripting uses preemptive of surgical technique and individual judgment (Gas et al., 2017). Previous study suggested that problem and scripting based learning (PSBL) method is a crucial tool of pre-operative prepared improvement and can cultivate spine residents' ability to use prior knowledge and cognitive frameworks flexibly to deal with problems during performance (Cong et al., 2017).

Virtual reality (VR) simulation has become an important part of all levels of education in the medical field. The ability of people to practice and learn in a safe and controlled environment makes them a valuable tool for initial training and continuous proficiency testing (Flurry et al., 2012). Kashif's research proves the effectiveness of using VR stimuli as a training tool for technical skills (Akhtar et al., 2015). Gasco and colleagues identified that computer-based simulation is an remarkable tool to teach non-experts how to operate efficiently and accurately technical process such as pedicle screw placement involving sequential learning, depth perception, and understanding three-dimensional anatomy (Gasco et al., 2014). Recently, with the development and innovation of the wearable technology (WT), such as Google glass, with high definition video recording or action camera, it is easy for surgeon to record surgical video from his own field of vision by wearable technology. Lee reported that medical professionals used Google Glass, a pair of eyeglasses designed to an optical head-mounted display, throughout the hospital. Through the glass, the user can intuitively master information (Lee et al., 2017).

We propose that WT will bring a lot of benefits for orthopedic OR nurse to develop specialized skills and team collaboration in PSBL. Nevertheless, few studies related to combine WT and PSBL been done to investigate features underlying efficiency. The purpose of this study was to evaluate the feasibility of WT and PSBL combination to develop specialized skills and team collaboration in orthopedic OR nurses.

2. Material methods

2.1. Participants

20 OR post-graduate-year-1 nurses were selected at random into the "conventional training" group and "WT combining with PSBL" group by a non-physician study staff and every group had 10 nurses. All the 20 OR nurses are Chinese Han women in northeast of China, and they had similar nursing and general operative experience and had no orthopedic operative experience. Our Institutional Review Board and Institutional Animal Care and Use Committee has reviewed and approved this research. All participants have signed informed consent to educational research.

2.2. Research design

100 fracture patients (Chinese Han in northeast of China) in line with indications for surgery were discussed and selected by the faculty of Department of Orthopedic Surgery, The First Hospital of China Medical University from 2017.1 to 2017.12. Recently, complex doctor-patient relationship and the busy clinical work have made it difficult for us to recruit qualified 100 fracture patients in a short time. The candidate cases were assigned for the OR nurses at random by a non-physician study staff and every OR nurses had five cases to deal with base on their own group.

The nurses of "Conventional training" group were trained by the traditional didactic model, after the theoretical training of orthopedic OR, following superior orthopedic OR nurses to complete pre-operative preparations and assist the superior nurses in performing orthopedic surgical operations. In comparison, WT&PSBL group don't attend theoretical training of orthopedic OR. They followed orthopedic surgeons to make ward rounds and taking part in the discussion about the information of patients including indications for surgery, pertinent physical tests and imaging and the plan of surgery, and wrote a scripting (< 30 points) about plans of surgical procedure including the perioperative management in accordance the actual circumstance of patients and relevant surgical nursing skills based on ward rounds and submitted to the superiors for auditing, who discussed with individual participant and gave feedback to modify the scripting. To avoid stereotyped writing, we demonstrated to WT&PSBL group how to write the scripting. In this group, one superior orthopedic OR nurse will assist the surgeon to perform an open reduction and internal fixation operation on a fracture patient wearing a Google glass. All WT&PSBL nurses can study the video to develop nursing skill and individual judgment.

The superior orthopedic OR nurse was in a blind before surgeries. In addition, the superior orthopedic OR nurse did not attend the morning conference to ensure blinding to what kind of method was used by the OR novice nurse to prepare for the candidate patient. After surgeries, the superior orthopedic OR nurse was asked to fill up the questionnaire with 10 statements for feedback. A scored bar to show the relationship between "preparedness" and "performance" was surveyed with Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), or Strongly Agree (5). The scores of the two groups were analyzed with means ± standard deviation. Questionnaires aimed to assess the benefits and preference of the two projects on training orthopedic OR novice nurses to obtain nursing skills and experience and then asked them for giving a scoring between 1 and 5 (1: lowest preference, 2: less preference, 3: Neutral, 4: preference, 5: strong preference). Using the *t*-tests of statistic method assessed the results.

3. Results

By design, every orthopedic OR novice nurse can attend 5 operations as the assistant nurse. Table 1 summarized mean scores for preparedness and performance feedback statement.

There were statistical significant differences between WT&PSBL Group and "Conventional Training" Group in pre-operative preparedness feedback statement ("I felt that the nurse checked the surgical instruments before starting the procedure", "The nurse knew the operation procedure steps", and "The nurse was well prepared for the operation procedure". $P \leq 0.05$) and Intra-operative performance feedback statement ("The nurse's performance was not affected by stress/anxiety", "The nurse was insightful and understood surgeon's directions", "The nurse delivered the right tool according to the procedure", and "The nurse was a good assistant to the operation". $P \leq 0.05$). All the feedback statement of "Conventional training" Group was found to have lower scores. Finally, the mean scores of overall total preparedness and performance feedback statement for the WT&PSBL group was higher than "Conventional training" Group ($P \leq 0.05$).

Table 2 listed the questionnaire of OR novice nurse's feedback about

Table 1
Preparedness and Performance feedback statement mean scores.

Feedback questionnaire statement		Conventional training group	WT & PSBL group
Pre-operative preparedness	1. I felt that the nurse checked the surgical instruments before starting the procedure.	4.00 ± 0.67	4.60 ± 0.52*
	2. The nurse knew and understood the relevant anatomy.	4.20 ± 0.63	4.50 ± 0.71
	3. The nurse knew the operation procedure steps.	3.80 ± 0.63	4.50 ± 0.53*
	4. The nurse was well aware of the operation procedure specific details that could have affected/changed the procedural steps/decisions.	4.00 ± 0.67	4.30 ± 0.67
	5. Overall, the nurse was well prepared for the operation procedure.	3.90 ± 0.74	4.60 ± 0.52*
	Mean score of pre-operative preparedness	3.98 ± 0.32	4.50 ± 0.37*
Intra-operative performance	6. The nurse's performance was not affected by stress/anxiety.	3.70 ± 0.67	4.40 ± 0.52*
	7. The nurse was insightful and understood surgeon's directions.	3.70 ± 0.95	4.50 ± 0.53*
	8. The nurse had better grasp of key procedure steps.	3.80 ± 0.63	4.30 ± 0.67
	9. The nurse delivered the right tool according to the procedure.	3.70 ± 0.67	4.40 ± 0.70*
	10. The nurse was a good assistant to the operation.	3.60 ± 0.84	4.40 ± 0.52*
	Mean score of intra-operative performance test	3.70 ± 0.29	4.40 ± 0.25*
	Total mean score of preparedness and performance	3.84 ± 0.25	4.45 ± 0.24*

the two training methods. In accordance with questionnaires, the novice nurse in WT- PSBL Group made significantly better total score than "Conventional training" Group (P ≤ 0.05). There were statistical significant differences between WT&PSBL Group with "Conventional training" Group in the "Training method was well designed.", "Teaching method made me confident.", "Training method was useful to improve operation nursing skills.", "I accomplished complete understanding of the operation procedure.", "I would like to repeat the experience.", "I developed individual judgment." and "The overall satisfaction of students with the method." (P ≤ 0.05).

4. Discussion

The rationale for recommending modern OR nursing education is that it helps the novice nurses to augments clinical practical experience and to develop nursing skills necessary for successful surgery. A great deal of time is needed to help them transition from students to professional nurses and to establish them as productive members of the surgical teams(Ball et al., 2015). Traditional methods are orthopedic OR nurses' training senses and experience to improve nursing skills and individual judgment of potential orthopedic OR nurses. Senses of intra-operative performance may help novice orthopedic OR nurses obtain nursing skills. Moreover, the experience of pre-operative preparation does not only teach preparing the surgical tools but also helps novice orthopedic OR nurses develop their judgment. They could develop their own judgment through writing a scripting before surgeries. Therefore practical training became basement of nursing education. Previous investigations identified that it may stimulate students' interest and enthusiasm, that students made actual operations on real patients (Li et al., 2013). WT&PSBL combined a real operation video from wearable technology and a scripting of pre-operative preparedness to better address these problems and then assessed the benefits of improved nursing education.

Many previous studies performed more advanced methods to improve training trainee performance. Lee and colleagues found that Google glass was the most lightweight and convenient device for holding and wearing throughout the long surgery time. Additionally, action cameras on Google glass can record and play back the process of spinal surgeries with developing of the device and applied program in the future (Lee et al., 2017). Golab's study showed that Google Glass as a new intra-operative monitor design example was fit for objective. Furthermore, the combination of the new display design and appropriate wearable technology could greatly deal with the selective dorsal rhizotomy procedure (Golab et al., 2016). Above studies supplied objectively that wearable technology played a crucial role in teaching non-experts highly technical procedural task through validated tools. All intra-operative performance feedback statements were significantly higher in WT&PSBL group. Because, the novice nurses of WT&PSBL Group tracked the intra-operative display through a projected screen positioned just from the experienced orthopedic OR nurse's line of sight. Real intra-operative videos through the eyes of the experienced orthopedic OR nurses allow the novice nurses to familiarize with key surgical structures and facilitate understanding of main operation steps. Visual input cannot be substituted by any other modality in establishing spatial relationship of vital structures and procedures steps. Wearing glass responds through both tactile and vocal feedback, which could provide the most benefit in improving intra-operative performance of inexperienced orthopedic OR nurses. Wearable technology has tremendous potential for OR nurses training and is constantly ratcheted up for expanding services. It was not surprising that the novice nurses can get more instruction and experience to improve their nursing skills from wearable technology. In short, the WT&PSBL Group got significantly positive feedback. Thus it should be included as part of operation nursing education whenever possible.

It is a long way to ask the novice nurses for their participation operations and perioperative management (Finnesgard et al., 2016). Even

Table 2
The questionnaire: Novice orthopedic operating room nurses' opinion on the effectiveness of the two training methods.

	Conventional training group	WT & PSBL group
1. Training method was well designed.	3.80 ± 0.42	4.50 ± 0.53*
2. Training method achieved our learning goals.	4.10 ± 0.74	4.50 ± 0.53
3. Teaching method made me confident.	4.20 ± 0.42	4.70 ± 0.48*
4. Training method was useful to improve operation nursing skills.	4.00 ± 0.67	4.60 ± 0.52*
5. Training method stimulated my interest.	3.90 ± 0.57	4.20 ± 0.63
6. Training method was effective.	4.00 ± 0.67	4.40 ± 0.52
7. I accomplished complete understanding of the operation procedure.	3.80 ± 0.63	4.40 ± 0.52*
8. I developed individual judgment.	3.90 ± 0.57	4.50 ± 0.53*
9. I would like to repeat the experience.	4.00 ± 0.47	4.60 ± 0.52*
10. The overall satisfaction of nurses with the method.	4.00 ± 0.47	4.50 ± 0.53*
Total mean score	3.97 ± 023	4.49 ± 0.20*

those of experienced orthopedic OR nurses need to follow the standard preparation method to read textbooks, know anatomy and surgeries, even review journal articles(Gas et al., 2017). Asking the novice nurses to follow a fracture operation video from the experienced orthopedic OR nurse's view and then write down key factors about critical surgical steps is active learning. There has no study to compare preparedness and performance in active and passive learning methods, that active learning methods are the combination of PSBL and wearable technology and passive learning methods are traditional methods. Our study identified that PSBL could make inexperienced orthopedic OR nurses efficiently finish pre-operative preparedness and wearable technology teaching method is benefit to intra-operative performance. Although WT&PSBL require considerable time and funding, its benefits well outweigh the efforts. Through operation vision, the novice nurses can directly view the operation process, extract quintessence and obtain feedback to stimulate their sense of performance and improve their operation nursing skills. It is worth taking time and effort for the staff to discuss the scripting written by the novice nurses and help them to better understand their assist's capabilities. What is more, WT&PSBL encourages nurses to act with potential decisions without real life consequences and help them to comprehensively understand surgery training content. Using WT&PSBL, it is temporarily possible to make inexperienced orthopedic OR nurses independently practice their plan and obtain experience from their shortcoming and fallibility without potential patient harm.

Teacher evaluations and nurses' feedback demonstrated that the novice nurses of WT&PSBL group acted better at pre-operative preparedness, intra-operative performance and had more enthusiasm. Moreover, the novice nurses of WT&PSBL group thought that the methods enriched their experience for improving their individual judgment and understanding of the operation nursing skills. Thus, they show greater satisfaction to WT & PSBL training method. The nurses' review of real operation video from wearable technology, discussion of the problems and scripting of the patients generates hypothesis that motivates further learning. Increasingly they independently and consciously study and discuss their learning issues under the experienced orthopedic OR nurses' supervision. WT&PSBL may benefit for stimulating nurses' passion and improving their judgment and ability of handling clinical problems. It may spend more time to prepare but obtain better experience. The statistical data revealed that WT&PSBL method in orthopedic OR nurses' training was high quality. Though WT&PSBL method teaches the novice nurses to understand interactions and then more deeply learn based on the transformation of experience, there are limitations on costing and time of WT&PSBL in orthopedic OR nurses training. So trainees and teachers may feel very tired because of the tight curriculum schedule. Thus in order to achieve educational benefit, trainees must effectively plan pre-operative preparedness and staff must accurately modify the scripting for implementing on regular basis. There may be bias because of small size samples. The data in our study suggested that WT&PSBL as a benefiting training method is an innovative concept. And it calls the continual study to assess the benefiting training methods.

5. Conclusions

WT&PSBL method is an innovative tool for training orthopedic OR

novice nurses for stimulating their passion and improving pre-operative preparedness and intra-operative performance and the ability of handling clinical problems. Despite there are the limitations in using WT & PSBL, it is an important first step to train qualified and experienced orthopedic OR nurses.

Recommendations

In the future study, we need enlarge the number of the candidate nurses to confirm or refute our findings.

Acknowledgments

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.nedt.2018.11.005.

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